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December 11, 1957

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Attn: [redacted]

Dear Al:

Enclosed please find three copies each of Progress Reports No. 10 and 11 covering the months of October and November, 1957, on our Project No. A-100.

Expenditures during October amounted to approximately $2,247.38, leaving an unexpended and uncommitted balance of $6,350.66. As yet we have not received our cost sheets for November so this amount will be reported in our next letter.

Sincerely yours,

[redacted] 25X1

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Project No. A-100

THICKNESS MEASUREMENT OF NON-METALLIC MATERIALS

Progress Report No. 11

for

[redacted]

25X1

Dec. 11, 1957

Copy No. 1

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THICKNESS MEASUREMENT OF NON-METALLIC MATERIALS

I. INTRODUCTION

This is a report of the progress on [redacted] Project No. A-100 for the period of November 1 to November 30, 1957. The purpose of this project is to develop an ultrasonic method of measuring the thickness of non-metallic materials, when access to one side only is possible. Apparatus for this task, which will work with metals and some glasses and plastics, is available commercially. However, other materials, such as concrete, cannot be measured with these devices because of the high attenuation of the ultrasound in the material. Again, there are commercially available instruments which will measure, by ultrasonic means, the thickness of concrete if transducers can be placed on both sides of the sample. The thickness is determined by measuring the longitudinal resonance frequencies of the sample or the travel time of a pulse in the sample. For reasons mentioned in previous reports, we have decided to concentrate on the latter, or pulse-echo, method. 25X1

The problem is then to produce an ultrasonic pulse, transmit it into the sample, and detect the arrival of the pulse reflected from the far side of the sample. The difficulties arise from the weakness of the return signal with respect to the other signals present. The interfering signals are for the most part due to the ringing of the transducer. If we are to use the sending transducer as a receiver, the ringing, or remnant oscillation, from the initial signal must be essentially zero when the returning pulse strikes the transducer. This represents a considerable amount of damping, for the frequencies used must be 200 kcps or lower and the travel time for the pulse in a three inch concrete block is only 30 microseconds, or about six periods of a 200 kcps wave.

It is not possible to avoid this problem by going to higher frequencies, for 200 kc represents a wavelength of slightly under an inch and many of the inclusions in a piece of concrete are of the order of an inch in size. Thus, there is already a considerable amount of attenuation due to scattering at 200 kcps, and higher frequencies could only drastically increase the attenuation.

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An alternative solution, still leaving aside the question of damping, is to use separate transmitters and receivers. The receiving transducer can be either concentric with or spatially separated from the transmitter. However, it has been found that there is some coupling of the two transducers through the mechanism of the waves along the surface of the sample. The interfering signal is, of course, less than that when a combined transmitter-receiver is used, but it is still large enough to obscure the signal one wishes to observe.

The problem then is two-fold: (1) The most effective means of damping the sender must be found; (2) ways must be sought to reduce the coupling of the two transducers by the surface wave.

II. PROGRESS OF WORK

One method of effectively reducing the ringing in the sending transducer involves the application of two pulses to the transducer, so spaced in time that the second pulse opposes the ringing due to the first pulse. The most successful system to date has used the two pulses applied to a cylindrical piece of barium titanate. The cylinder has a two inch outer diameter and a one inch inner diameter and is one inch high. The electrodes are on the flat ends of the cylinder. One end of this transducer is placed against the sample and a second barium titanate rod, one-half inch in diameter and one-half inch high, is placed in the center of the hole and used as a receiver.

At times this system has given clear thickness indications in both three inch and six inch concrete blocks. At other times no clear readings could be obtained, because of the presence of surface waves. The problem here is almost obviously one of slight changes from experiment to experiment which greatly affect the production of surface waves. So far, however, we have not been able to trace the difficulty to the source.

In one attempt to investigate this problem, the sending "doughnut" was cemented to the concrete block. This, as was expected, gave a result in the wrong direction - that is, the amplitude of the surface wave was greatly increased. More experiments on this problem are definitely indicated.

Some time was spent investigating a variation of the double pulse method in which the two pulses are applied to two separate transducers placed one on top of the other. This arrangement seemed to offer no advantages over the more usual procedure of applying both pulses to one transducer.

Earlier experiments with small (one inch in diameter by 1/4 inch thick) barium titanate transducers had indicated that a fair amount of damping could be obtained by backing the ceramic with bakelite. This was tried on one of the larger pieces (two inch diameter by one inch thick) of barium titanate, but was less successful in reducing the ringing of the larger transducer.

In an attempt to improve both the damping and the coupling, another barium titanate cylinder (1-1/2 inches long and 1-1/2 inches in diameter, with a 1/8 inch wall thickness) was covered at one end with thin rubber sheeting. The resulting container was then filled with glycerine. It was expected that the glycerine would damp the ringing and that, if the unit were to be held slightly above the concrete surface so that the only contact between the transducer and the sample would be the rubber face, slightly stretched by the weight of the glycerine, the coupling for longitudinal waves would be increased while the couplings for other modes were decreased. In neither aspect did the unit perform according to expectations.

III. FUTURE PLANS

It would seem that the best avenue of approach is the pulse-echo technique, probably with a concentric sender-receiver transducer pair. Three new barium titanate ceramics have been ordered to enable a thorough investigation of the concentric sender-receiver system. These transducers should arrive early in December. Following brief experimentation with these a technical report will be prepared covering the work to December 15, 1957.

IV. NOTEBOOKS

Data contained in this report are recorded in Notebook No. C-6516.

V. CONTRIBUTING PERSONNEL

Work on this project was performed by [redacted] under 25X1
the supervision of [redacted] 25X1

Respectfully submitted,

[redacted] 25X1

APPROVED:

[redacted] 25X1

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